

OPACITY BASED INTERFERENCE TEXTURE

Field of Invention

The present invention relates to a method of generating a coloured or shaded
5 texture to be displayed on a display device or printer.

The invention has been developed primarily for use in generating background
effects for displayed or printed matter. However, it will be appreciated that the
textures generated may be applied to any suitable subject, including sprites, lettering,
and the surfaces of three-dimensional representations.

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Background

A number of prior art systems have been developed to generate various types
of textures. Typically, these systems involve modulation of existing functions, such as
Perlin noise functions, reaction-diffusion or vector fields. Alternatively, an existing
15 image may be modulated using these or similar functions. However, such approaches
tend to be relatively processor intensive, which may be a disadvantage where speed is
important.

There is an ongoing interest in generating visually interesting textures in a
relatively simple, fast manner, for use with all types of text and graphics manipulation
20 and display. In particular, there is an ongoing need for visually interesting
parameterised textures which can be applied to font characters and relatively easily
customised for particular applications without the need for large amounts of manual
input from a user.

25 Summary of Invention

The present invention provides a method of generating a coloured or shaded
texture for images to be displayed on a display device or printed, the method including
the steps of:

(a) providing a plurality of shape elements, each shape element defining a surface;

(b) providing each of the shape elements with an opacity which varies over its surface;

5 (c) arranging the shape elements in an overlapping fashion; and

(d) rendering the shape elements for output to a printer, storage or a display device, such that the overlapping opacities generate a coloured or shaded texture.

10 Preferably the shape elements are regular geometric shapes, and are all of the same general shape. It is also preferred that the shape elements be of a similar size. In a particularly preferred embodiment, the shape elements are circles.

Preferably, the shape elements are positioned at predetermined points within a closed curve, such as an outline of a font character.

15 Other aspects of the invention are described in the following detailed description.

Brief Description of Drawings

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

20 Figure 1 is a surface plot showing opacity values across a unit square region, determined from a circle centred at one corner with opacity varying from 1 at its centre to 0 at its perimeter;

Figure 2 is a surface plot similar to that in Figure 1, determined from two circles centred at adjacent corners;

25 Figure 3 is a surface plot similar to that shown in Figures 1 and 2, determined from three circles centred at three corners;

Figure 4 is a surface plot similar to that shown in Figures 1, 2, and 3, determined from four circles centred at the corners;

Figure 5 shows a surface plot of opacity values across a unit square region in which the focus is 0;

Figure 6 shows a surface plot similar to that shown in Figure 5, in which the focus is 0.5;

5 Figure 7 shows a shaded texture overlayed with a flat shaded letter "L" (designated 21), generated in accordance with the preferred embodiment of the invention;

Figure 8 is a shaded texture similar to that shown in Figure 7, with the overlapping circles rendered using an OVER operator;

10 Figure 9 is a shaded texture similar to that shown in Figure 8, with a focus of 0.95;

Figure 10 is a shaded texture similar to that shown in Figures 8 and 9, with a focus of 1.5, and with the opacities rendered using a PLUSW operator;

15 Figure 11 is a shaded texture similar to that shown in Figures 8 to 10, in which opacity varies from 0.75 at the focal point to 0.25 at the perimeters of the shapes;

Figure 12 is a shaded texture similar to that shown in Figures 8 to 11, in which opacity varies from 0.25 at the focal point to 0.75 at the perimeters of the shapes;

Figure 13 is a schematic diagram of computer apparatus for use in implementing preferred embodiments of the invention;

20 Figure 14 is a flowchart showing the steps involved in implementing a preferred form of the invention; and

Figure 15 is font character "m" to which there has been applied a shaded texture in accordance with the preferred embodiment.

25 **Detailed Description of Preferred Embodiments**

Referring to the drawings, the preferred embodiment of the invention provides a method of generating a coloured or shaded texture for images to be displayed on a display device or printer. The basic steps in performing the preferred embodiment are set out in the flowchart 1400 of Figure 14. Initially, in step 1401, a plurality of shape

elements are provided. Each shape element defines a surface, and in the preferred form, is a regular polygon or circle. Each of the shaped elements is provided with an opacity in step 1402, and the shape elements are then arranged in an overlapping fashion in step 1403. Usually, the area within which the shape elements are arranged
5 will be bounded by a closed curve, such as the edges of a font character. Alternatively, if the preferred embodiment is being used as a means of generating a background texture, no boundary other than the edges of the image itself will apply.

The overlapping shape elements are then rendered in step 1404 for output to a printer 1405, display 1407 or memory 1406. It will be appreciated that each of
10 components 1405, 1406 and 1407 are implemented on a computer system, such as that discussed below in relation to Figure 13.

In the preferred, coloured embodiments, a coloured texture is generated by means of interference in colour space when overlapping shapes of varying opacity are composited. In this way, the resultant texture is effectively encoded in the colour (or
15 shade) and opacity of the shapes, and is not realised until rendering.

The method requires that a plurality of overlapping shapes be provided, thereby to ensure the requisite interference. Typically, the shape elements are regular geometric shapes, and will usually be of uniform size and shape. However, different sizes and shapes may be mixed to provide varying visually interesting textures.

As shown in the various figures, it is particularly desirable that the shape
20 elements be circles, although other shape elements such as squares, hexagons or other regular polygons (not shown) may be used to provide different textures.

Each shape has associated with it a focal point 1 defined relative to its perimeter. As shown in Figures 5 and 6, maximum opacity usually occurs at the focal
25 point 1, and decreases towards a perimeter 2 of the circle. Opacity is shown on a vertical scale 4. As shown in Figure 6, moving the focal point 1 towards the perimeter 2 skews the opacity with relation to the unit square, which, when composited with other shape elements, causes different visually interesting textures to be generated.

The opacity of each shape can vary between its focal point 1 and perimeter 2 according to any suitable function, although linear interpolation is used in the preferred embodiments. The use of linear interpolation helps to ensure a relatively consistent opacity value across the final texture.

5 Consistency of the opacity is also improved when the shapes are relatively evenly distributed across the texture region, and is of particular importance if the texture is to be used for further compositing operations. Figures 1 to 4 show the effects of overlaying opacities of neighbouring circles, each having a focus of 0. In Figure 1, a circle 6 (only one quarter of which is shown) disposed in the horizontal plane and
10 centred at a first corner 8 of a unit square 10 exhibits a relatively steep opacity gradient 12. Figure 2 adds a circle to an adjacent corner, 14, thereby reducing the overall opacity differential across the unit square as a whole. Figure 3 adds yet another circle, whilst Figure 4 adds a final circle to the last free corner of the unit square 10. As
15 shown in Figure 4, the effect of multiple overlapping circles having relatively constant spacing and linear opacity gradients tends to produce a relatively constant opacity across the area in which the circles are disposed. There are, in this case, some minor "bumps" associated with the adding of the overlapping circles. However, these do not depart greatly from an opacity of 1. For example, a central bump 16 with an opacity of about 1.2 is the furthest deviation from an opacity of 1.0 across the whole unit square.
20 An algorithm such as mesh fitting, well known to those skilled in the art, may be used to generate reasonably equidistant points at which to place the shape elements.

A focus parameter dictates the relationship of the focal point 1 to its associated perimeter 2. In a preferred embodiment, a default value of 0 indicates that the focal point 1 is at the circle's centre, as shown in Figure 5, whilst a value of 1 indicates that
25 the focal point 1 is on the perimeter of the circle. Figure 6 shows the case where the focal point 1 is shifted 0.25 units towards the perimeter 2.

In the preferred form, the available focus parameter values vary between the centre of the circle and the perimeter 2, although in other embodiments the focus parameters can extend beyond this range to allow focal points outside the perimeter 2.

Varying the focus parameter results in colour and opacity discontinuities which can give an impression of substantial shape not offered by other texture-generation algorithms. For example, in Figure 9 there are shown discontinuities 18 in brightness as the colours and opacities "wrap" around. This occurs as composited opacities which exceed a
5 predetermined maximum opacity respectively are remapped to a lower opacity. An analogous colour "wrapping" takes place as colours are composited in combination with varying opacities. For focal points 1 which exceed a focus parameter of 1.0, this "wrapping" can become more noticeable, as shown in Figure 10. The sharp black-white discontinuities 20 are examples of this. In Figures 7 to 10, there appear regions
10 of gradually changing shade 22, which imply solidity or three-dimensionality.

The colour of each component shape is independent of the opacity function used, and may be a flat colour, a colour blend, or even a shade. Flat colour is preferred due to ease of implementation, although other visually interesting patterns may be achieved by varying the colours of the various shape elements. Various
15 compositing operators may be used to calculate overlapping shape opacity, and include those typically used in computer graphics, such as: OVER (Figures 8 and 12), XOR, PLUSC (Figures 7, 9, 11), and PLUSW (Figure 10). It will be appreciated that the PLUSC operator causes a colour component to clamp on overflow, whilst the PLUSW operator results in wrapping of the colour component on overflow. The PLUSW
20 operator is of particular interest, because it introduces colour discontinuity resulting from colour wrapping without introducing opacity discontinuities. This is why the texture in Figure 10 appears smoother, as shown in region 23, without the opacity discontinuities introduced by other operators.

Referring to Figure 11, there is shown a texture generated by the method of
25 the invention, whereby the opacity at the focal point is 0.75, and the opacity of the perimeter is 0.25. This results in definite opacity discontinuities 24 at the edges of circles, because the opacity of each circle does not taper to 0 at the perimeter. Figure 12 illustrates a similar arrangement, in which the opacity is 0.75 at the perimeter and 0.25 at the focal point, composited using an OVER operator. The relatively high

opacity at the edge of each circle generates even more distinct opacity discontinuities 26 than are shown in Figure 11. These examples demonstrate the quite different effects which can be generated by altering a relatively small number of parameters.

The colour space in which the overlapping shapes are rendered has a direct
5 bearing on the resultant texture. CIE $L^*a^*b^*$, a colour space based on the human eye's sensitivity to colour, is the preferred choice of colour space, as it results in colours combining in a non-intuitive way to produce visually interesting results. However, the method will work for other colour spaces commonly used in computer graphics, such as RGB or CMY, and can give visually different results for each.

10 Varying any of the many perimeters of the shape elements will correspondingly vary the resultant texture. Accordingly, the size of the shape elements, the geometric shapes represented, the density of the shape elements, the opacities and opacity gradients as well as the colour space and compositing operators, can be selected and altered at will to generate interesting textures.

15 In a particularly preferred embodiment, the shaded texture described is applied within a closed curve defined by a boundary. One particular application of this embodiment is shown in Figure 15, in which an outline 1500 of a font character "m" has been filled with a texture 1501 generated in accordance with one of the preferred
20 embodiments described above. The shape elements (circles 1502 in this embodiment) are positioned within the outline 1500, either randomly or by means of a known point distributing method such as wave-propagation from boundary points. It will be appreciated that the relatively low processor requirements for filling the outline of a font character means that font textures can be generated and manipulated by users "on the fly". Also, new texture parameters falling within the scope of the present invention
25 can be defined and immediately applied to existing text characters, or to text characters immediately as they are typed or otherwise input by an operator.

30 The preferred embodiments of the invention are typically implemented as a computer application program hosted on the Windows™ operating system developed by the Microsoft Corporation. However, those skilled in the art will recognise that the

described embodiment can be implemented on computer systems hosted by other operating systems. For example, the respective embodiments can be performed on computer systems running Unix, OS/2, and DOS. The application program has a user interface that includes menu items and controls that respond to mouse and keyboard
5 operations. The application program has the ability to transmit data to one or more printers either directly connected to the host computer or accessed over a network. The application program also has the ability to transmit and receive data to a connected digital communications network (for example, the internet).

The preferred embodiment of the invention can be practiced using a
10 conventional general-purpose computer system, such as the computer system 1340 shown in Figure 13. The application program is implemented as software executed on the computer system 1340.

The computer system 1340 comprises a computer module 1341, input devices such as a keyboard 1342 and mouse 1343, and output devices including a printer 1357
15 and a display device 1356. A modulator/demodulator (modem) transceiver device 1352 is used by the computer module 1341 for communicating to and from a communications network, which is accessed via a telephone line or other functional medium. The modem 1352 can be used to attain access to the internet, and other network systems.

The computer module 1341 typically includes at least one processor unit 1345,
20 a memory unit 1346 formed from semiconductor random access memory (RAM) and read only memory (ROM), input/output (I/O) interfaces including a video interface 1347 and an I/O interface 1348 for the keyboard 1342 and mouse 1343.

A storage device 1349 is provided and typically includes a hard disk drive 1353 and a floppy disk drive 1354. A CD-ROM drive 1355 is typically provided as a
25 non-volatile source of data. The components 1345 to 1349 and 1353 to 1355 of the computer module 1341 communicate via an interconnecting bus 1350 in a manner which results in a conventional mode of operation of a computer system 1340 as is well known to those in the relevant art. Examples of computers on which the embodiments can be practiced include IBM-PC and compatibles, and some sparcstations.

Typically the application program of the preferred embodiment is stored on the hard disk drive 1353 and controlled using the processor 1345. Intermediate storage of the program, print list and any data fetched from the network can be accomplished using the semiconductor memory 1346, in concert with the hard disk drive 1353 as
5 required. In some instances, the application program can be supplied to the user encoded on a CD-ROM or floppy disc, or alternatively can be read by the user from the network by the modem device 1352.

A major advantage of the present invention is that the generated textures do not rely upon modulation of existing functions, such as Perlin noise functions, reaction-
10 diffusion, or vector fields. Furthermore, source images for use with such modulation are not required, which results in the method requiring relatively little in the way of memory or processor resources when implemented on a computer system. As well as the visually interesting results obtainable by the invention, the potential reduction in computer resources provides an additional advantage over prior art coloured or shaded
15 texture generation schemes.

Although the invention has been described with reference to a number of specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.